

RI Statewide Hazard Risk and Vulnerability Assessment

Warwick Pilot Results

The methodology was applied to perform a vulnerability assessment of census tracts in the city of Warwick as a pilot study. Results from this analysis are discussed in the attached report (submitted under separate cover) entitled “Warwick Pilot Study”.

State of Rhode Island Results

Mapping Information

Two sets of maps were created to represent the data, relative maps and absolute maps. Relative maps present hazard, exposure, and combined scores on a five step colored scale from “Lowest” to “Highest”. This allows for greater ease in interpretation of any given map, but presents a problem when comparing “Highest” and “Lowest” scores between different maps. This problem is due to the fact that a “Highest” value on one map may not represent the same range of scores as a “Highest” value on another map.

For example, on the Relative Flood Hazard Map, a “Higher” value represents a Hazard Score of 19 to 27. The lowest score is 0 and the highest score is 45. However, on the Relative Hurricane Hazard Map, a “Higher” value represents a Hazard score of 61 to 80. In the first case, the interval between each category is 8, where the interval between each category in the later case is 19. Thus the descriptive category “Higher” will not mean the same thing between two maps, which may graph data of different scales with different intervals between each interpretive category.

In order to allow for comparison between maps, a set of absolute maps were created that graphed hazard, exposure, and comparison scores on a uniform scale and with equal intervals between each category. These maps have a ten step colored scale and an equal interval of 10 between each category. While absolute maps allow for comparability between hazard and exposure categories, they are often much less descriptive since the range of scores for some categories are quite small compared to others.

Both relative maps and absolute maps are included to allow for a greater variety of interpretation and analysis.

Hazard Scores

Hazard Scores were determined for each census tract based on the methodology described above. Table 16 shows the hazard scores tabulated for each of the seven hazards considered, as well as the total hazard score and average hazard score for each census tract. In addition, statewide totals are shown at the bottom of the table.

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The attached maps in Appendix C show the distribution of hazard scores throughout the state. In addition, a summary map of all hazards is shown for ease of reference.

Table 16. Hazard Scores for Rhode Island Communities (sum of census tracts)

Town	AREA (sq.miles)	Wind Score	Flood Score	Earthquake Score	Tornado Score	Hail Score	Snow Score	Temperature Extreme Score	Total Score	Average Score
Barrington Total	10.3	860.0	234.0	420.0	112.0	280.0	600.0	560.0	3066.0	438.0
Bristol Total	11.2	1200.0	135.0	480.0	128.0	320.0	400.0	640.0	3303.0	471.9
Burrilville Total	57.1	960.0	63.0	510.0	136.0	340.0	850.0	680.0	3539.0	505.6
Central Falls Total	1.3	740.0	36.0	300.0	80.0	200.0	500.0	400.0	2256.0	322.3
Charlestown Total	41.7	680.0	144.0	210.0	56.0	140.0	175.0	280.0	1685.0	240.7
Coventry Total	62.3	1160.0	81.0	480.0	128.0	320.0	550.0	640.0	3359.0	479.9
Cranston Total	28.9	3820.0	360.0	1950.0	520.0	1300.0	3250.0	2600.0	13800.0	1971.4
Cumberland Total	28.1	1180.0	117.0	600.0	160.0	400.0	1000.0	800.0	4257.0	608.1
East Greenwich Total	16.3	720.0	63.0	270.0	72.0	180.0	225.0	360.0	1890.0	270.0
East Providence Total	13.9	2720.0	225.0	1410.0	376.0	940.0	2350.0	1880.0	9901.0	1414.4
Exeter Total	58.3	240.0	0.0	90.0	24.0	60.0	75.0	120.0	609.0	87.0
Foster Total	51.8	180.0	18.0	120.0	32.0	80.0	200.0	160.0	790.0	112.9
Glocester Total	56.8	500.0	27.0	240.0	64.0	160.0	400.0	320.0	1711.0	244.4
Hopkinton Total	44.0	600.0	54.0	210.0	56.0	140.0	175.0	280.0	1515.0	216.4
Jamestown Total	13.8	480.0	54.0	180.0	48.0	120.0	150.0	240.0	1272.0	181.7
Johnston Total	24.3	1180.0	18.0	510.0	136.0	340.0	850.0	680.0	3714.0	530.6
Lincoln Total	19.0	740.0	45.0	360.0	96.0	240.0	600.0	480.0	2561.0	365.9
Little Compton Total	23.0	160.0	18.0	60.0	16.0	40.0	50.0	80.0	424.0	60.6
Middletown Total	13.7	800.0	36.0	300.0	80.0	200.0	250.0	400.0	2066.0	295.1
Narragansett Total	16.9	1180.0	198.0	390.0	104.0	260.0	325.0	520.0	2977.0	425.3
New Shoreham Total	11.0	300.0	27.0	90.0	24.0	60.0	75.0	120.0	696.0	99.4
Newport Total	9.2	1880.0	306.0	720.0	192.0	480.0	600.0	960.0	5138.0	734.0
North Kingstown Total	45.3	1760.0	297.0	690.0	184.0	460.0	575.0	920.0	4886.0	698.0
North Providence Total	5.8	1400.0	81.0	690.0	184.0	460.0	1150.0	920.0	4885.0	697.9
North Smithfield Total	24.7	480.0	27.0	210.0	56.0	140.0	350.0	280.0	1543.0	220.4
Pawtucket Total	8.8	4880.0	117.0	2160.0	576.0	1440.0	3600.0	2880.0	15653.0	2236.1
Portsmouth Total	27.3	1120.0	216.0	420.0	112.0	280.0	350.0	560.0	3058.0	436.9
Providence Total	18.7	10980.0	486.0	5850.0	1560.0	3900.0	9750.0	7800.0	40326.0	5760.9
Richmond Total	40.7	200.0	18.0	90.0	24.0	60.0	75.0	120.0	587.0	83.9
Scituate Total	54.7	500.0	99.0	270.0	72.0	180.0	450.0	360.0	1931.0	275.9
Smithfield Total	27.7	920.0	72.0	420.0	112.0	280.0	700.0	560.0	3064.0	437.7
South Kingstown Total	63.5	1580.0	171.0	540.0	144.0	360.0	450.0	720.0	3965.0	566.4
Tiverton Total	30.8	880.0	54.0	330.0	88.0	220.0	275.0	440.0	2287.0	326.7
Warren Total	7.5	800.0	198.0	330.0	88.0	220.0	275.0	440.0	2351.0	335.9
Warwick Total	36.9	5400.0	684.0	2400.0	640.0	1600.0	2875.0	3200.0	16799.0	2399.9
West Greenwich Total	51.4	240.0	0.0	90.0	24.0	60.0	75.0	120.0	609.0	87.0
West Warwick Total	8.1	1480.0	99.0	660.0	176.0	440.0	925.0	880.0	4660.0	665.7
Westerly Total	31.5	1880.0	189.0	570.0	152.0	380.0	475.0	760.0	4406.0	629.4
Woonsocket Total	7.9	2260.0	99.0	1110.0	296.0	740.0	1850.0	1480.0	7835.0	1119.3

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Exposure Scores

Exposure Scores were determined for each census tract based on the methodology described above. Table 17 shows the exposure scores tabulated for each of the exposures considered, as well as the total exposure score and normalized score for each census tract. Exposure scores are summarized by individual exposure subcategories as well as major categories (environmental, economic, social, and critical facilities). In addition, statewide totals are shown at the bottom of the table.

The attached maps in Appendix C show the distribution of summary exposure scores (environmental, economic, social, and critical facilities) throughout the state. In addition, a summary map showing all exposures is shown for ease of reference.

Exposure scores were also summarized by community. The community level results were obtained by adding the census tract exposure scores together. These maps are also shown in Appendix C.

Table 17. Rhode Island Exposure Scores by Community (sum of census tracts)

Town	Area (sq. miles)	Critical Facilities Score	Normalized Social Score	Normalized Social Score	Environmental Score	Normalized Environmental Score	ECONOMIC SCORE	Normalized Economic Score	Total Exposure Score	Normalized Total Exposure Score	
Barrington Total	10.31	74.6	7.5	104.0	10.4	6.0	2.0	308.0	38.5	492.6	123.2
Bristol Total	11.21	62.7	6.3	224.0	22.4	4.6	1.5	384.0	48.0	675.3	168.8
Burrillville Total	57.05	74.4	7.4	164.0	16.4	13.8	4.6	363.0	45.4	615.2	153.8
Central Falls Total	1.30	52.5	5.3	238.0	23.8	1.2	0.4	50.0	6.3	341.7	85.4
Charlestown Total	41.72	46.7	4.7	57.0	5.7	14.2	4.7	147.0	18.4	264.9	66.2
Coventry Total	62.28	122.5	12.3	161.0	16.1	38.4	12.8	372.0	46.5	693.9	173.5
Cranston Total	28.87	265.7	26.6	896.0	89.6	14.2	4.7	1473.0	184.1	2648.9	662.2
Cumberland Total	28.14	89.5	9.0	212.0	21.2	19.8	6.6	380.0	47.5	701.3	175.3
East Greenwich Total	16.32	45.5	4.6	79.0	7.9	4.2	1.4	243.0	30.4	371.7	92.9
East Providence Total	13.95	165.6	16.6	711.0	71.1	14.0	4.7	1004.0	125.5	1894.6	473.7
Exeter Total	58.33	34.3	3.4	20.0	2.0	13.8	4.6	63.0	7.9	131.1	32.8
Foster Total	51.83	33.6	3.4	20.0	2.0	19.6	6.5	64.0	8.0	137.2	34.3
Glocester Total	56.79	60.4	6.0	57.0	5.7	15.4	5.1	159.0	19.9	291.8	73.0
Hopkinton Total	43.98	22.9	2.3	54.0	5.4	13.2	4.4	150.0	18.8	240.1	60.0
Jamestown Total	13.81	22.0	2.2	43.0	4.3	9.4	3.1	156.0	19.5	230.4	57.6
Johnston Total	24.35	66.5	6.7	210.0	21.0	22.4	7.5	442.0	55.3	740.9	185.2
Lincoln Total	18.98	96.7	9.7	131.0	13.1	20.4	6.8	354.0	44.3	602.1	150.5
Little Compton Total	22.96	8.8	0.9	14.0	1.4	11.6	3.9	44.0	5.5	78.4	19.6
Middletown Total	13.72	56.6	5.7	114.0	11.4	12.4	4.1	160.0	20.0	343.0	85.8
Narragansett Total	16.85	97.5	9.8	120.0	12.0	6.2	2.1	271.0	33.9	494.7	123.7
New Shoreham Total	10.96	17.0	1.7	19.0	1.9	5.2	1.7	75.0	9.4	116.2	29.1
Newport Total	9.16	135.4	13.5	338.0	33.8	11.2	3.7	552.0	69.0	1036.6	259.2
North Kingstown Total	45.33	94.0	9.4	186.0	18.6	22.6	7.5	451.0	56.4	753.6	188.4
North Providence Total	5.78	66.7	6.7	321.0	32.1	2.4	0.8	238.0	29.8	628.1	157.0
North Smithfield Total	24.72	61.1	6.1	66.0	6.6	23.6	7.9	119.0	14.9	269.7	67.4
Pawtucket Total	8.85	222.6	22.3	1257.0	125.7	8.2	2.7	1748.0	218.5	3235.8	809.0
Portsmouth Total	27.35	53.5	5.4	106.0	10.6	16.6	5.5	310.0	38.8	486.1	121.5
Providence Total	18.75	790.3	79.0	3873.0	387.3	22.2	7.4	3511.0	438.9	8196.5	2049.1
Richmond Total	40.71	36.8	3.7	20.0	2.0	19.6	6.5	58.0	7.3	134.4	33.6
Scituate Total	54.75	60.1	6.0	53.0	5.3	13.0	4.3	165.0	20.6	291.1	72.8
Smithfield Total	27.75	61.0	6.1	123.0	12.3	16.6	5.5	290.0	36.3	490.6	122.7
South Kingstown Total	63.50	183.3	18.3	175.0	17.5	28.6	9.5	445.0	55.6	831.9	208.0
Tiverton Total	30.83	39.5	4.0	110.0	11.0	11.0	3.7	264.0	33.0	424.5	106.1
Warren Total	7.50	54.0	5.4	155.0	15.5	5.4	1.8	253.0	31.6	467.4	116.9
Warwick Total	36.88	259.1	25.9	815.0	81.5	17.0	5.7	1713.0	214.1	2804.1	701.0
West Greenwich Total	51.40	30.8	3.1	18.0	1.8	18.6	6.2	75.0	9.4	142.4	35.6
West Warwick Total	8.11	87.6	8.8	319.0	31.9	4.8	1.6	550.0	68.8	961.4	240.4
Westerly Total	31.48	70.6	7.1	216.0	21.6	7.2	2.4	361.0	45.1	654.8	163.7
Woonsocket Total	7.93	236.5	23.7	703.0	70.3	5.8	1.9	666.0	83.3	1611.3	402.8

Combined Scores

The Combined Scores were determined for each census tract based on the methodology described above. Every combination of individual exposure and hazard was considered for each individual census tract, resulting in a total of 273 combined scores for each census tract. For analysis purposes, these scores were combined into statewide aggregates and are summarized in Table 18.

In addition, the attached maps in Appendix C show the distribution of combined scores throughout the state for the following combinations.

- Total Absolute Hazard Score * Total Absolute Exposure Score
- Individual Hazard Scores * Total Absolute Exposure Score (i.e., seven maps, one for each hazard type)
- Individual Exposure Scores * Total Absolute Hazard Score (i.e., four maps, one for each exposure category)
- Individual Hazard Score * Individual Exposure Score (for illustrative purposes, elderly populations at snow risk and schools at earthquake risk)

In addition, a summary map showing all of these combinations together is shown for ease of reference.

STATEWIDE SUMMARY TABLE OF COMBINED SCORES

Exposure		Hazard						
		Wind	Flood	Earthquake	Tornado	Hail	Snow	Temperature
Critical Facilities	Marinas	5300	1386	1980	528	1320	1925	2640
	Shelter	163202	13619	73320	19552	48880	104618	97760
	Schools	53880	4082	24120	6432	16080	32940	32160
	Hospitals	1612	47	702	187	468	1008	936
	Fire	16250	1650	6825	1820	4550	8580	9100
	Police	4290	374	1716	458	1144	2113	2288
	Water	27360	3812	11736	3130	7824	15180	15648
	Railroad	720	32	252	67	168	240	336
	Government	2712	281	1116	298	744	1290	1488
	Critical Facilities Sum	275326	25284	121767	32471	81178	167893	162356
Critical Facilities Average	27533	2528	12177	3247	8118	16789	16236	
Social Vulnerability	Population (total)	165940	12969	76770	20472	51180	112425	102360
	Nonwhite	38500	1539	19440	5184	12960	31375	25920
	Poverty	32640	1899	15750	4200	10500	24725	21000
	Over 65	90660	8073	41130	10968	27420	59125	54840
	Disabled	44800	3582	20850	5560	13900	30225	27800
	No High School	152820	10899	70800	18880	47200	105900	94400
	Public Assistance	43460	2628	20550	5480	13700	31500	27400
	No Vehicle	29320	2151	13860	3696	9240	21350	18480
	Renters	191820	15426	88170	23512	58780	128775	117560
	Non-English Speakers	15940	693	7740	2064	5160	12550	10320
	Social	805900	59859	375060	100016	250040	557950	500080
Social Normalized	80590	5986	37506	10002	25004	55795	50008	
Environmental	CERCLIS sites	21288	2441	9072	2419	6048	11970	12096
	Protected Species	15760	1314	6270	1672	4180	7025	8360
	Scenic Vistas	1680	153	690	184	460	800	920
	Environmental Sum	38728	3908	16032	4275	10688	19795	21376
	Environmental Average	12909	1303	5344	1425	3563	6598	7125
Economic	Construction	132920	12060	59490	15864	39660	82200	79320
	Manufacturing	120860	10044	54750	14600	36500	77600	73000
	Wholesale	132540	11223	60330	16088	40220	85975	80440
	Hotels	242440	21618	109230	29128	72820	153400	145640
	Agriculture	45940	4248	20310	5416	13540	26850	27080
	Service	105320	9594	46500	12400	31000	63375	62000
	Retail	256220	22086	115380	30768	76920	163275	153840
	Financial	105420	9216	47070	12552	31380	66225	62760
	Dom	89840	8514	39870	10632	26580	53550	53160
	Economic Sum	1231500	108603	552930	147448	368620	772450	737240
	Economic Average	153938	13575	69116	18431	46078	96556	92155
TOTALS	Total Exposure	2351454	197654	1065789	284210	710526	1518088	1421052
	Average Total Exposure	587864	49413	266447	71053	177632	379522	355263

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Mitigation Opportunities

The risk scoring maps were presented to numerous planners, businesspeople, and state officials in order to identify mitigation opportunities. These meetings included:

1. Several meetings with Pamela Pogue, State Flood Plain Coordinator and Project Impact Coordinator.
2. Presentation to the Rhode Island Statewide Hazard Mitigation Planning Committee 2/2001.
3. Presentation to the Rhode Island Showcase State Hazard Assessment Committee 2/2001. This committee consisted of state officials, representatives from FEMA, major utilities, the insurance industry, and private business.
4. Presentation to insurance industry representatives 3/24/2001 at Amica Mutual Insurance, one of the largest property insurers in Rhode Island.
5. Presentation to Rhode Island Showcase State Steering Committee 8/1/2001

Each of these meetings yielded mitigation opportunities that will be pursued by the state. The mitigation opportunities can be divided into two broad categories:

1. Macroscopic policy initiatives. Based on the overall hazard and risk assessment results, several key initiatives were identified to mitigate key hazard/exposure combinations. These initiatives include:
 - a. Statewide adoption of IBC2000 building code. The new building code includes provisions for improved design of buildings for hurricanes/extreme wind events, earthquakes, floods, and snowstorms that are consistent with the hazard levels identified in this study. The new code provides a major improvement in hazard-based design when compared to the existing code (BOCA 1996 with State Amendments). For example, the existing code uses a uniform snow load throughout the state, whereas hazard maps and the experience of the project team suggest a higher potential loading for northern parts of the state.
 - b. Encourage responsible development of high risk coastal areas.
 - c. Foster public awareness of disaster risk, focusing on flood, hurricane, snowstorm, and earthquake risk.
2. Microscopic/focused mitigation programs

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- a. Accelerate development of community hazard mitigation plans in high-risk communities identified in this report.
- b. Review NFIP policy concentration in high-risk flood census tracts, and encourage further participation in program

All of these mitigation opportunities will be incorporated in the state hazard mitigation plan (409 Plan) being prepared by the Rhode Island Emergency Management Agency concurrent with this vulnerability assessment.

In addition, the following areas were identified for further study:

1. Further evaluation of Warwick flood for critical facilities, social, environmental, and economic exposure
2. Need additional study of nursing homes, day care centers, assisted living facilities under critical facilities category
3. Need additional study of tourism industry exposure to hurricane events. This analysis should include seasonal hazard scores, with higher hurricane hazards during peak tourist season. RIEDC maintains data on the tourist population
4. Suggest preparation of scenario analyses for key hazards and economic exposures for detailed losses. For example, simulate a repeat of the 1938 hurricane and compute economic losses statewide. Similarly, a flood analysis for a 500 year flood could be performed to compute total economic losses within flooded areas
5. Environmental study could include analysis of shoreline change maps in relationship to hurricane and coastal flooding hazards.

Commentary on Approach and Results

The following issues related to the technical methodology and results were identified during the course of this study:

1. Census tract scaling issue for economic data. Particularly for economic data, census tracts tend to distort the results due to differences in size (e.g. Lincoln has only 2 census tracts, so these come up with very high economic exposure scores due to large expanse of area covered, while individual census tract in Providence come up lighter). To address this issue, it is recommended that exposure results be summarized at the community level for output maps. These maps have been included in Appendix C for comparison with the census tract level data.

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2. Missing data for individual census tracts can skew the final combined hazard/exposure results. For example, some census tracts were found to be missing in the exposure databases used for this study. The combined results therefore indicate lower levels of risk in these missing census tracts, suggesting a false level of variation in risk within the region. For this reason, census tract level results should be used with care and consideration for this issue when viewing the final results. In situations where this effect is pronounced, it is recommended that community-level results be used in lieu of census-tract level results.
3. Link between community and statewide data. Ideally, data collected on a community level would be incorporated into the statewide analysis. However, since different levels of detail exist in each community for exposure data, it may be impossible to directly incorporate much of the community-level information. For example, one community may have information on the exact location of every emergency shelter, while an adjacent community may only know the total number of shelters within the community. It is recommended, however, that the detailed community level data be used for local validation of the results (see below). If detailed information is desired for incorporation directly into the statewide analysis, an alternative procedure might be to use an “information quality factor” for each community in order to account for the differences in data resolution. Communities with higher resolution of data should receive a lower risk score (for example, by using a lower quality factor), due to the improved knowledge of assets at risk. This issue was explored during this study using sensitivity analysis, but quality factors were not used in the final results.
4. Need for localized validation. Statewide results may suggest very high levels of risk in individual census tracts. However, it is recommended that a detailed analysis be performed to validate any such conclusion. In this study, we have performed detailed validation of flood hazard risk in the City of Warwick on a higher resolution scale in order to validate the statewide results.

References

- “Community Vulnerability Assessment Tool”, NOAA Publication #NOAA/CSC/99044-CD, National Oceanic and Atmospheric Administration Coastal Services Center, Charleston, SC, 2000.
- “Minimum Design Loads for Buildings and Other Structures”, Publication ASCE 7-98, American Society of Civil Engineers, Reston, VA, 2000.
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- HAZUS 99 MapInfo Version, Eastern Region Build 257, Federal Emergency Management Agency, Washington, DC 1999.
- HAZUS 99 MapInfo Version Supplemental Data, CD #65 Rhode Island Vol. DT65.V02, Federal Emergency Management Agency, Washington, DC 1999.
- “International Building Code (IBC2000)”, International Code Council, Inc., March 2000
- **The Rhode Island Geographic Information System (RIGIS)** is a consortium of government and private organizations employing computer and communications technology to manage and use a collective data base of comprehensive geographically related information. See URL at <http://www.planning.state.ri.us/GIS/GISHOME.HTM>.